A CASE OF HYDROCEPHALUS IN AN EGYPTIAN OF THE ROMAN PERIOD.

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THE skull and certain bones of the skeleton now to be described were found by Mr R. Engelbach, in a cemetery of Roman date at Shurafa, not far from Helouan, in Egypt, while working for the British School of Archæology there, during the winter season 1911–1912, and Professor Flinders Petrie very kindly allowed the writer to examine and report upon them.

The bones are those of a man of at least thirty years of age, probably more. The line of union of the epiphysis of the crest of the ilium is completely obliterated; and though the cranial sutures, with the exception of a small part of both lambdoids, are still open externally, certain of them have commenced to close on the inner side. The teeth are considerably worn, and might well be those of a man past middle life.

This man, whose stature has been estimated from the femur and tibia by Pearson's formula (1), appears to have been about 1·506 m. in height. He was the victim of some disease of the brain, probably hydrocephalus, which not only caused the growth of the skull to the remarkable proportions shown in the drawings, but was also responsible for a partial paralysis of the left side, which has left its mark in a very definite manner upon the bones concerned.

THE SKULL.

The skull is nearly perfect. A portion of the occipital bone in the neighbourhood of the foramen magnum has been broken away, involving the posterior border of this aperture. The lower part of the posterior wall of the right maxilla has also disappeared, including the adjacent part of the alveolus and second molar tooth, thus exposing the antrum on this side. All the teeth have dropped out recently, except the first molar on the right side and the second bicuspid and first molar on the left. In the mandible only the three molars on each side remain, the rest of the teeth having recently disappeared.

Norma verticalis.—The skull is of a wide pointed oval shape (fig. 1), and in this aspect appears somewhat irregularly formed, so that the left zygomatic arch is visible while the right is hidden. There is also a slight but definite bulging in the region of the right parietal eminence. On the frontal bone, just to the right of the middle line and 2 cm. in front of the coronal suture, there is an irregular shallow oval depression with a roughened floor, possibly due to an injury. It does not involve the inner table. The surface of the skull from just behind the frontal eminences, as far back as the superior curved line of the occipital bone, and on each side reaching to the attachment of the temporal fascia, is covered with innumerable minute pits, interspersed with slightly larger foramina, a condition perhaps associated with periostitis. The coronal and sagittal sutures are still open.

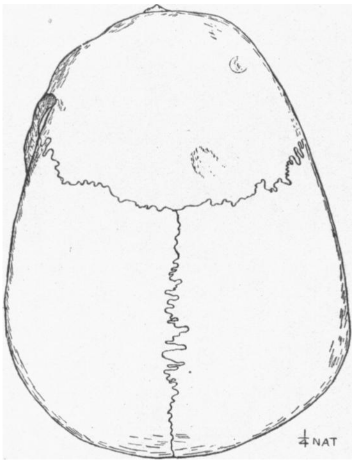

FIG. 1.—Norma verticalis, showing asymmetry of skull.

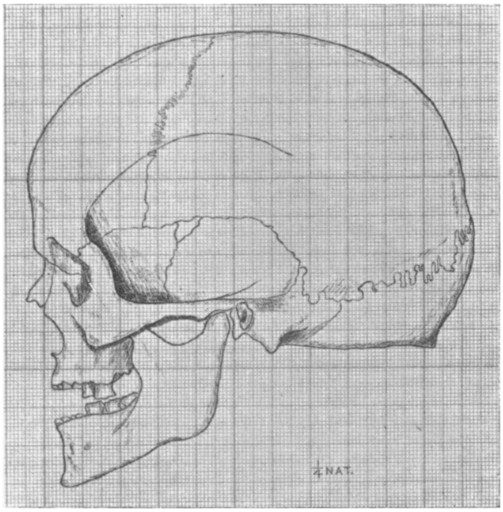

FIG. 2.—Left norma lateralis of hydrocephalic skull.

Norma lateralis (fig. 2).—From this aspect the chief points of interest are the prominence of the forehead, which overhangs the face and thus imparts to the latter a slightly opisthognathous appearance; the disproportion between the facial and cranial parts of the skull, and the great size of the ala temporalis of the sphenoid. At the junction of the great wing of the sphenoid with the squamous temporal there is a very marked bulging of the cranial wall (not shown in the drawing). The squamous temporal itself is small, as compared with the other bones of the cranial vault, and appears not to have shared in the general increase of size which has affected them. The mastoid processes are only of medium size, and above each process, between it and the supramastoid crest, the bone has the appearance of being deeply hollowed out (sulcus supramastoideus of Waldeyer). This has probably been produced by the pull of the muscles attached to the base of the process rather than by any actual excavation of the bone. In this connexion attention may be drawn to the greatly developed inion and superior curved line, forming a well-marked torus occipitalis, which is certainly the result of unusual strain upon the fasciæ and tendons attached in this region.

Norma basalis (fig. 3).—In this drawing the skull is arranged, as in all the normæ, in the Frankfort plane. Owing, however, to the prominence of the forehead, and the slight backward slope of the face, already referred to,

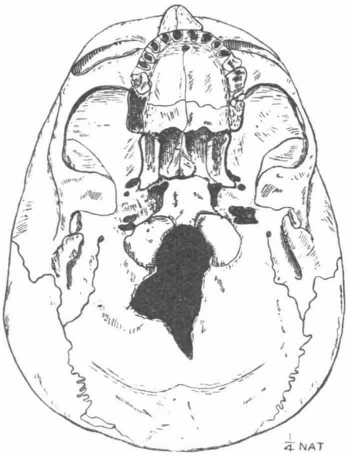

FIG. 3.—Norma basalis.

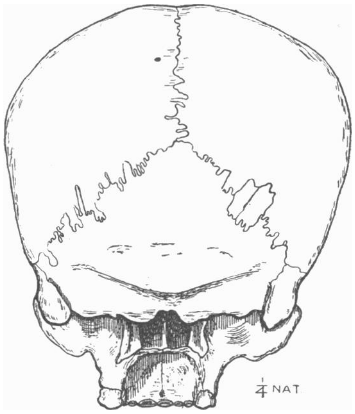

FIG. 4.—Norma occipitalis.

certain of these parts are exposed which are not usually visible in a normal skull in this position. The asymmetry in the region of the zygomatic arches noticed in norma verticalis is also exhibited here, as well as the bulging of the right parietal eminence. A marked flattening of the occipital condyles, especially at their posterior edges, is probably to be attributed to the enormous weight of the head.

Norma occipitalis (fig. 4).—This view of the skull is important as showing the condition of the sutures in this region. It will be noticed that, with the exception of an ossicle in the right lambdoid suture, no Wormian bones are to be seen. From this it may be inferred that the interlocking of the sutures had taken place before the onset of the disease, or at least before the disease had progressed far enough to interfere with their normal arrangement, as the complexity of the sutures, and the number and size of the Wormian bones formed in them, are well-recognised features of the infantile hydrocephalic skull. The writer is indebted to Professor Thane for drawing his attention to this.

Norma facialis (fig. 5).—The face, though fairly large and well developed, is not in proportion with the immense calvaria, being actually smaller than is the case in many normal skulls. With the mandible in position it is of quadrangular form. The orbits are elliptical in shape and obliquely placed; the nose is prominent and slightly asymmetrical, having a definite inclination to the left; the nasal bones themselves are wide, and the nose as a whole is broad, with a large nasal aperture. The margins of the

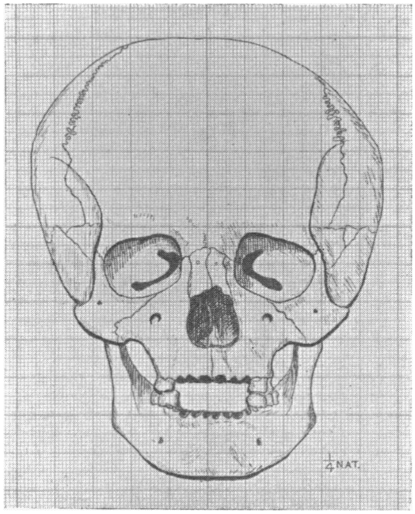

Fig. 5.—Norma facialis.

aperture terminate in the double prenasal type, and the nasal spine is well marked. The face itself is also somewhat asymmetrical.

The mandible is a large well-developed bone with a prominent chin and a broad, rather low ramus, the angle of which is somewhat everted. All muscular markings are well-defined.

Teeth.—As mentioned above, most of the teeth have dropped out. Those which remain, though well worn, are in perfect condition, and there is no sign of caries. The wisdom teeth are present in the mandible; but in the maxillæ the alveolus of the right side, which should contain this tooth, has been broken away, while on the left side, although the alveolus has also been broken, sufficient of it remains to make it practically certain that there never has been a third molar on this side. Furthermore, when the mandible is articulated, with the teeth in apposition, it is clear that the lower third molars worked upon the upper second molars, thus accounting for the wear of the wisdoms in the mandible.

Interior of Cranium.

An examination of the interior of this skull reveals the following features. On the right side the coronal suture is entirely closed, except for a distance of about 4 cm. from the middle line. On the left side the suture is open for quite half its length from the middle line, but for the remainder is closed, although it is still easily visible. The sagittal suture is completely open except for a very small part near the lambda, where it is closing; the lambdoid suture is also closing in the same region, but is open further out. The grooves for the sinuses are small, as are also the Pacchionian depressions, but the impressions of the cerebral convolutions on the parietal bones are unusually deep and large. The pituitary fossa, examined by means of a laryngoscopic mirror, is not unduly large, but its floor contains a foramen which may be the remains of the cranio-pharyngeal canal, though it does not appear to be open right through.

Dimensions of Skull.

A complete list of the measurements made upon this great skull will be found at the end of this paper; but certain of them will now be specially referred to.

The greatest length of the skull is not, as is usually the case, the glabello-occipital diameter, owing to the fact that the forehead projects in advance of the glabella. The maximum length is therefore between the most projecting part of the forehead, which in this case is in line with the frontal eminences, and the occiput, and this measures 235·5 mm. The ophryo-occipital length follows this, measuring 230 mm.; and the glabello-occipital is the shortest of the three, with 229·5. This relation of the antero-posterior diameters to each other is also found in children and in some negroes in whom the glabellar development is slight.

The maximum breadth is 184 mm., and the cephalic index is therefore 78·1 if the *greatest* length measurement is employed, but rises to 80·1 when calculated from the glabello-occipital diameter in the usual way.

If the length and breadth measurements of this skull be compared with those of other recorded cases of macrocephalic crania, they will be seen to be greater than any of those quoted, particularly in the antero-posterior diameter. The following table gives the results obtained by Humphry (2) from five macrocephalic skulls, and also two cases published by Campbell (3), one of hydrocephaly and the other an instance of cerebral hypertrophy (megalocephaly). Humphry's figures were given in inches, but have been expressed in millimetres here for greater ease in comparison.

Reference.		Glab.-occip. length.	Max. transverse diameter.	Cephalic index.	Basi-bregmatic height.
Humphry's cases.	5. Æt. 43	208·2	165·1	79·3	152·4
	6. Romano-British	213·3	167·6	78·5	144·7
	7.	220·9	172·7	78·1	157·5
	8.	213·3	170·1	79·7	139·7
	9.	215·9	182·8	84·6	157·5
Campbell's cases.	Hydrocephaly, æt. 29	208	172	82·6	155
	Megalocephaly, æt. 29	196	152	77·1	141
Egyptian—Hydrocephaly		229·5	184	80·1	158

In order to test the relative increase in size of the bones chiefly concerned in the enlargement of the cranial vault, measurements were made from the nasion to the bregma, along the arc of the frontal bone, thence to the lambda, and from this last point to the opisthion. Unfortunately, owing to the break already mentioned in this region, it was only possible to estimate the position of the opisthion. Sufficient of the border of the foramen magnum remains to show that this opening was small, and by careful comparison with other crania it was concluded that it could not possibly have measured more than 3 cm. in its long axis. As the total measurement from the lambda to the basion is 18·2 cm., this gives the length of the occipital squama from lambda to opisthion as 15·2 cm. This calculation was made to enable a comparison to be instituted with other crania, both normal and diseased, and it appears from the table given below that the bones have shared fairly equally in the enlargement, though, in relation to the frontal and parietals, the occipital has increased the least. This is what might be expected in hydrocephalus; but while it will be noticed that, in undoubted cases of this disease, the lack of growth in the occipital bone as compared with the enormous increase in the frontal and parietals is a striking feature, it is not specially marked in the Egyptian skull, which indeed approximates to the normal English skull which has been added for comparison.

In order that the difference between diseased and normal conditions may be appreciated at a glance, the relation of the parietal longitudinal arc to the occipital arc has been worked out in each case in the form of an index:

$$\frac{\text{Occipital arc} \times 100}{\text{Parietal long. arc}}.$$

Case.	Frontal long. arc.	Parietal long. arc.	Occipital long. arc.	Total arc.	Index (parieto-occip.).
	cm.	cm.	cm.	cm.	
Normal English . . .	15	14	12·5	41·5	89·2
Hydrocephalic Egyptian .	18	17·8	15·2	51	85·4
Cerebral hypertrophy (Campbell)	14·6	16·4	12·4	43·4	75·6
Hydrocephalic infant (University College) . . .	18·2	23	11·2	52·4	48·7
Hydrocephalic (Campbell's case)	19	20·5	6·7	46·2	32·6

The indices in the last column show in a very striking manner the contrast between the Egyptian skull, as regards growth of the occipital bone, and the two cases of undoubted hydrocephalus. In both of these the growth of the occipital bone has been much retarded, and in consequence the parieto-occipital index is very low. In the case of cerebral hypertrophy, though the occipital bone has suffered, it is to a much less degree, and the index is correspondingly high.

In hydrocephalus it is usual to find considerable thinning of the cranial walls, and this even in cases reaching adult life, according to the figures given by Campbell. In the following table the thickness of the cranial walls in the Egyptian skull is compared with a normal Egyptian from the same cemetery at Shurafa, an aboriginal Australian, and the two cases already cited from Campbell's paper.

Case.	Frontal bone (eminences).		Parietal bone (eminences).		Occipital bone (above sup. curved line).	
	R.	L.	R.	L.	R.	L.
	mm.	mm.	mm.	mm.	mm.	mm.
Hydrocephalic Egyptian . .	8	8·5	5	6	8·5	9
Normal Egyptian . . .	6	5·5	5·5	6·5	8	7·5
Australian aboriginal . .	8	9	6·5	6·5	5	5
Hydrocephalus (Campbell) .	3 mm.		...		5 mm.	
Cerebral hypertrophy (Campbell)	10 „		...		12 „	

From the above it is clear that the Egyptian hydrocephalic skull does not conform to the condition exhibited in Campbell's case of hydrocephalus, but rather tends to be somewhat thicker, at least in the frontal and occipital regions, than the normal skull from the same cemetery. Too much stress, however, must not be laid upon these figures, as great variations are found to exist in normal crania, and further, it is possible to obtain quite different readings within a small area of the same bone, owing to the varying thickness produced by the cerebral convolutions and sulci.

Another measurement of interest is the height of the face. This measures only 71 mm. for the upper face, as against 78·5 mm. in the modern English skull. Nevertheless, the total length of face, which is 121·5 mm., only differs from that of the English skull, which is 128 mm. in length, by 6·5 mm., showing that the lack of growth has chiefly affected the upper face, the mandible having been little if at all influenced by the changes in the rest of the skull, except perhaps in the direction of overgrowth, this being necessitated by the increase in length of the basisphenoid.

	Egyptian.	English.
Length of palate	51	53
Length from basion to post-nasal spine	49	39
	100	92

As the palate in the English skull is 2 mm. longer than that in the Egyptian, there is a difference of 8 mm. in the length from basion to posterior nasal spine, all of which is due to increased growth of the basisphenoid. The mandible has likewise grown to keep pace with this increase in the base of the skull; but though, as has just been shown, there is a difference of 8 mm. in the length from basion to nasal spine, the Egyptian mandible only measures 3 mm. more than that of the English skull, when both are placed with the condyles against the vertical on Broca's board. This apparent discrepancy is explained by the following facts. The position of the basion in relation to the glenoid fossæ is different in the two skulls, for whereas in the English skull it lies approximately in line with the Glaserian fissure, in the Egyptian cranium it is well behind this fissure, and more nearly in a line with the centre of the external auditory meatus (see fig. 3). In other words, the glenoid fossæ in the Egyptian lie further forward than in the English skull, and this to some extent obviates the necessity for such an increase in the length of the mandible as would otherwise be required by the increased growth of the skull base. But a further interesting point emerges from the comparison of the two mandibles, for it is found that, although they are nearly of the same total length (Egyptian 120 mm. and English 117 mm.), there is a great difference in the relative length of the parts. For while the alveolar arch in the English jaw is long, narrow, and pointed, and forms nearly 56 per cent. of the total length of the jaw from condyles to symphysis, in the Egyptian the arch is short and rounded, and constitutes only 48·3 per cent. of the total length, 51·7 per cent. being taken up by the broad sloping ramus, as against 44 per cent. in the English mandible. From these figures, then, it is clear that the increased length in the mandible, spoken of above, has taken place principally by alterations in the position and breadth of the ramus, the distance between the condyles and the last molar teeth being 10 mm. greater than the corresponding distance in the English jaw.

Capacity and Circumference of Skull.

The capacity of this great skull was kindly estimated by Miss Ryley, who has had large experience in this work in Professor Karl Pearson's Biometric Laboratory. Miss Ryley obtained no less than 2901·4 c.c. as the capacity, which by Welcker's scale, as quoted in *Quain's Anatomy*, "Osteology," vol. ii., part i., p. 83 note, gives a brain-weight of 2756·3 grammes. The largest brain recorded is that of an epileptic idiot, which weighed 2850 grammes, the cranial capacity being 2966 c.c. This was recorded by van Walsem, *Neurolog. Centralb.*, 1899, No. XIII. If the relation between capacity and weight in this case be employed in the Egyptian skull, then the capacity given above, 2901·4 c.c., gives a brain-weight of 2787·5 grammes, a difference of only 62·5 grammes from that of the largest hitherto recorded.

The circumference measures 660 mm., as against 647·7 in the largest of Humphry's cases, and 643 in Campbell's case of hydrocephalus. In the same author's case of megalocephaly, the circumference was 595 mm.

THE LIMB BONES.

It has already been mentioned that the cerebral disease from which this man suffered was responsible for a condition of hemiplegia affecting the left side of the body, and that all the bones of that side illustrate the changes which such a loss of power entails. The bones of both sides will now be considered, beginning with the humeri. In the following pages all the bones which were secured and brought to England are described.

Humeri.

When these two bones are placed side by side, it is not so much the feebler development of the left bone that attracts attention as the unusual robustness of the right (fig. 6). The *left* bone indeed appears perfectly normal in its development, though it resembles the lighter-built bone of a woman rather than that of a man, and it further agrees with the female type in the smallness of the articular surfaces. In one other character, viz. length, it not only differs markedly from the right, but is an exception to the rule that the left humerus is usually the shorter of the two, for in this instance it is much the longer. The *right* humerus is especially remarkable for its enormous development at the site of attachment of the deltoid and pectoralis major muscles, and there can be little doubt that these two muscles are chiefly responsible for the conditions existing in the upper half of the shaft. Apart from this, however, the whole bone is massively developed, with larger extremities and more extensive articular areas than exist in the left bone. The right bone also possesses a fairly large supratrochlear foramen. It is unusual to find this foramen in well-developed bones, and it is commoner on the left side than on the right, and in women than in men.

In the following table the dimensions of the two humeri are compared :—

	Right humerus.	Left humerus.
	mm.	mm.
Maximum length	284	302
Oblique length	281	298
Diameter of head, vertical	45·5	43
Diameter of head, transverse	43·5	40
Measurement of head along curve, vertical	64	60
Measurement of head along curve, transverse	60	52
Lower extremity, transverse (capitell. and trochlea combined)	46·5	42
Lower extremity, antero-posterior diameter of flange of trochlea	30·5	25
Maximum girth of shaft	·91	70

From the above comparison it will be noticed that the right humerus exceeds the left in every dimension except that of length, in which it is greatly surpassed With regard to the measurements of the head, the difference, not only in extent of the articular area, but also in the general robustness of the upper extremity, is best expressed by the measurement taken along the curve of the articular surface, in which a difference of 8 mm.

is found to exist in favour of the right bone in the transverse direction. This marked contrast between the extent of the articular areas in the two bones is of great interest in view of the well-recognised differences between the sexes in this respect; and as in this particular instance the difference is obviously associated with the feebler development of the left bone consequent upon the hemiplegic condition, while the massiveness of the right may be fairly correlated with the greater use to which this arm was put, the natural inference from this is, that the larger size of articular areas generally, in the male sex, is a direct result of the greater amount of muscular work

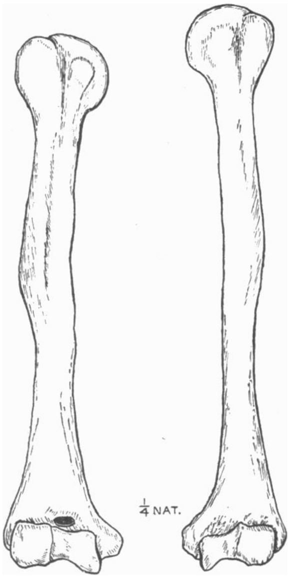

Fig. 6.—Right and left humeri.

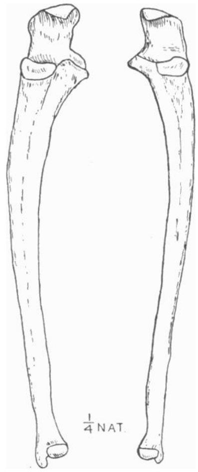

Fig. 7.—Right and left ulnæ.

done by them. Tempting, however, as such a theory undoubtedly is, it is not borne out by the facts, for amongst negroes, where women do quite as much work as men, and frequently a great deal more, the articular areas are not found to be correspondingly larger. Probably the true answer is that the size of articular surfaces varies directly with the robustness of the bone, as apart from actual length; but as size depends on muscular development, and men being usually more muscular than women, the articular areas are in agreement. The fact that the articular surface of the right humerus is usually a little larger than that of the left bears this out, seeing that most people are right-handed, and that the right is the more muscular of the two arms.

The difference in girth in the two bones is remarkable, and it is of interest to notice that, while the left bone has suffered in circumference through lack of muscular power, its growth in length has not been impeded. The right bone, on the other hand, has increased in girth by excessive muscular exercise, apparently at the expense of growth in length. This throws an interesting sidelight on the conditions of growth, illustrating as it does, on opposite sides of the same body, the well-known association of muscularity with shortness of stature and thick-set build, and long lanky growth with poor muscular development.

The Ulnæ.

In these bones there is nothing remarkable to describe. There is the same difference in size of the shaft and articular ends (fig. 7) as was noticed in the humeri, only to a somewhat less degree. As regards total length, the right bone exceeds the left by 1 mm., the measurements being 240 and 239 mm. respectively, taken from the top of the olecranon to the lower articular surface.

The radii are absent, but their length, as estimated from the ulnæ, amounts to 210 mm. and 213 mm. for the right and left bones respectively; thus the combined length of the left humerus and radius would be greater by 20 mm. than the same bones on the right side.

PELVIS (fig. 8).

This is very small, and the individual bones, like those of the rest of the skeleton, exhibit differences according to the side.

The *right* hip bone, except as regards size, appears to be normal. There is, however, one peculiarity which was pointed out by Professor Fawcett, to whom the writer showed the bones, and that is the limitation of the acetabular articular area to the iliac and ischiatic segments, the pubic portion taking no part in the articulation. This anomaly is present on each side, and is probably related to some peculiarity in the mode of progression.

Another feature is the notching of the articular surface in the acetabulum for the reception of the ligamentum teres at the point of its attachment to the head of the femur. This is comparatively common, at least to some degree, in the majority of bones examined, though it seems to be rather better marked in female bones—though further work is required to substantiate this. In the case under consideration it is a striking feature of the acetabulum, and points to an excessive *adduction* of the femur, or, what amounts to the same thing so far as results are concerned, a marked tilting of the pelvis downwards and to the left.

The *left* hip bone, although at first sight not strikingly different from the normal, is found on close examination to have suffered from the general left-sided lack of development. The ilium is flatter than usual, so that when viewed from the outer aspect it lacks the double curvature of the normal bone. The crest is thin throughout, and towards its posterior end there is a large shallow notch where the bone is thinner than elsewhere. This is the position of origin of certain fibres of the erector spinæ group of muscles, and the diminution of the bony surface at this point bears eloquent testimony to the condition of the muscle on this side of the body. The anterior superior spine is unfortunately broken away, but the bone below it and the anterior inferior spine are thin and poorly developed, as compared with the right side.

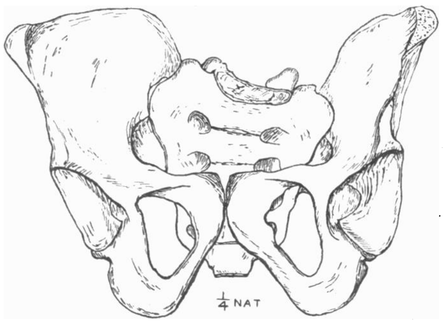

FIG. 8.—Pelvis. Note the deformity of the sacrum, and the lack of development of its left ala as well as of the left iliac bone. The left side of the pubic arch is, however, more strongly developed than the right.

The ilio-sciatic notch is definitely wider than on the right side, which measures 37 mm. from the ischial spine to the anterior border of the lowermost point of the auricular surface, as against 48 mm. on the left side. In this it somewhat simulates the female, and it is of interest to notice that there is a tendency to the formation of a pre-auricular groove on this side. This latter condition is probably the result of freer movement at the joint due to lack of muscular support, with consequent strain and stretching of the ligaments of the sacro-iliac joint. At the same time, the actual articular area is more extensive on the left side, and in this particular as well as in its general shape, which is quite different from that on the right bone, resembles the female type.

The acetabular cavity on the left side calls for special remark owing to its shallowness and ill-formed character. This want of development is apparently a direct result of the absence of the normal body weight on this side, and the uncontrolled action of the muscles in permitting irregular movements of the head of the femur in the socket. As a result the acetabulum is quite abnormal in shape, and its margin is rounded and indefinite, while the articular surface is roughened and uneven in adaptation to a similar unevenness on the head of the femur. The notch in the articular area for the reception of the ligamentum teres, which was so well seen on the right side, has its place taken here by a deposit of new bone. When the head of the femur is articulated with this acetabulum, it is clear that its movements are very limited, flexion and extension being particularly affected owing to the shape of the articular surfaces; and the small amount of flexion that is possible is accompanied by a considerable amount of external rotation.

The whole of the superior ramus of the pubis is thin and attenuated as compared with that on the right side; but the inferior ramus of the pubis and the ramus of the ischium are, on the other hand, stronger and better developed than the corresponding parts on the right side. This is at first sight paradoxical, as this is the only part of the bones of the left side which has not suffered more or less from the paralytic condition. The attenuation of the pubic arch on the right side may be reasonably attributed to complete lack of use of the adductor muscles, *not* in this instance from paralysis, but from the simple fact that the tilting of the pelvis to the left, and the lack of support from the left limb, rendered the adductor group useless on the right side. Adduction could not be practised owing to the powerlessness of the left limb to support the body during the operation; and further, by the tilting of the pelvis referred to, the right limb was forced into a constant position of adduction. The explanation of the greater strength of the pubic arch on the paralysed side is more difficult, but it is possible that the position of the left limb, which, as will presently be shown, was one of nearly constant internal rotation, threw a strain upon the muscles arising from the arch, which was probably increased by the tilting of the pelvis already mentioned, and still further by the spastic nature of the paralysis. There is a noticeable difference in the weight of the two bones, the right weighing just under 5 oz., and the left almost exactly 1 oz. less.

The index of the pelvic brim, which is only 68·2, shows it to be markedly platypellic, the transverse diameter measuring 110 mm. and the antero-posterior 75 mm.

Sacrum.

This is the only part of the vertebral column which was preserved, but it throws some light on the probable shape of that column.

The bone may be considered to be normal as regards its general shape and composition, though it is rather narrower and more slender than is usual. It is in the base that irregularity is apparent. Here a general tilting of the body of the first sacral vertebra to the left is obvious, accompanied by a lack of development of the left ala, which both in the antero-posterior and transverse directions is smaller than the right side. The transverse process portion is also modified, being drawn out into a thin point projecting backwards, in contrast with the thickness and bluntness of that on the right. The left superior articular process is likewise much modified, being smaller than its fellow and very irregular in shape. There is a want of definition of the edges of the articular area, which is common to all of the bones of the left side and is very noticeable here. When the sacrum is placed in position between the hip bones, the asymmetry becomes more apparent (fig. 8), and it is plain that the whole pelvis was tilted to the left owing to the want of support from the left lower limb. This would produce a lateral curvature of the lumbar region convex to the left, which we see commencing in the first sacral vertebra, with in all probability a compensatory curve of the thoracic region to the right.

The sacrum measures 100 mm. in its greatest length, and 99 mm. in breadth. It therefore belongs to the dolicho-hieric class.

FEMORA.

The differences which have been shown to exist in the upper limbs, and in the opposite sides of the pelvis, are very prominently displayed in the lower limbs. This might be anticipated in view of the weight which these have to bear, and the more so in this case, where the left limb was at least partially paralysed, thus throwing the major part of the body weight on the right side.

If we take the bones in turn and examine them in detail, we find the *right* femur to be a short stout bone, which in shape and general appearance is practically normal. There are, however, one or two points of interest to which reference must be made. In the first place, there is a complete absence of the normal torsion met with in the vast majority of femora. For when the bone is laid on the table the head, instead of being lifted from the surface upon which the bone is lying, touches it, while the great trochanter, upon which the majority of normal femora rest when in this position, does not in this case take any part in the support of the bone, being separated from the surface by a distance of about 5 mm. In other words, the head and neck of the right femur, instead of being rotated forwards, actually turn backwards, thus illustrating what Warren (4) has called "negative torsion." This observer did not get a single case of "negative torsion" in 113 right femora which he examined, and only found one example in a left bone, so that it is evidently a rare condition.

In striking contrast to the condition of the right femur, the left bone is found to suffer from an exaggerated amount of "positive torsion." In the drawing (fig. 9) this has been illustrated by placing the heads of the two bones on the same flat surface. When this is done an extraordinary internal rotation of the lower extremity of the left femur is revealed, such that the external surface looks almost directly forward and the patellar articular surface is only just visible.

Very varying degrees of torsion may be found normally, but it is quite exceptional to find two such extremes as are here illustrated in one skeleton.

Another point of special interest in the right femur is found in the very marked hollowing out of the internal condyle for the attachment of the posterior crucial ligament. Not only is the excavation of the bone unusually deep, but its extension forwards encroaches upon the articular surface of the internal condyle, and to some extent limits this area. It should also be noticed that the most posterior portion of the articular surface of each condyle, instead of being rounded, is distinctly flattened. This suggests a very constant flexion of the joint.

The *left* femur presents a very strong contrast to that just described. As already mentioned, there is an excessive amount of torsion, which is accompanied by a flattening of the shaft from side to side, such that in its narrowest part, at the level of the nutrient foramen, it measures only 15·5 mm. in width. At the same level the right bone measures 22 mm. This gives the appearance of a pilastering of the bone, but it is not a true pilaster, for the antero-posterior diameter is in no way increased; it is merely apparent, and is due to the loss of thickness in the shaft. It was pointed out by the writer, in a paper published in this Journal (5) some years ago, that platycnemia of the tibia is produced by a similar loss of width rather than by any actual increase antero-posteriorly, and consequently is found in slender bones rather than in those of a more robust type.

The shape of the head is very much modified in correspondence with the abnormal form of the left acetabulum already described. It is flattened and at the same time somewhat elongated in the vertical direction, thus to some extent losing the normal spherical appearance. The pit for the attachment of the ligamentum teres is a shallow, poorly marked depression, and this agrees with the filling up of the notch in the acetabular articular surface designed to accommodate this ligament during adduction of the limb. The small trochanter appears unusually well marked, but this is almost certainly a secondary result of the diminution of bone around this process. The great trochanter has suffered with the rest of the bone; it is smaller than the right, and the markings for the insertion of muscles are much modified.

With regard to the lower extremity of the bone, there are certain points of interest which must be described. The chief of these is the

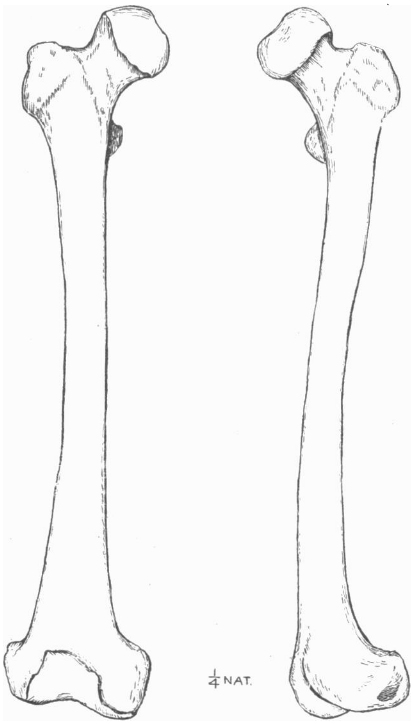

Fig. 9.—Right and left femora. Note the internal rotation of the lower extremity of the left bone, although the heads of the two bones are in the same plane.

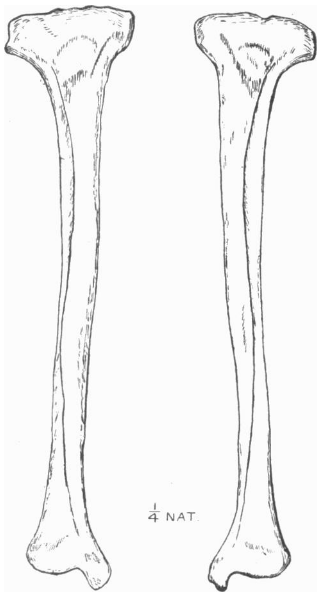

Fig. 10.—Right and left tibiæ. The left is slightly wider than the right bone.

reduction in the extent of the tibial articular surface as distinct from the patellar. This reduction chiefly affects the breadth of the internal condyle, which, in its widest portion, is 5 mm. less than the corresponding part on the right bone; the external condyle, as compared with that on the opposite limb, being little altered. Here again, as on the right side, the posterior crucial ligament occupies a larger extent of the outer surface of the internal condyle than is usual, and encroaches upon the tibial articular surface; but the excavation in this case is nothing like so deep, owing, no doubt, to the general lack of use of the limb, and, in consequence, of the joint. The patellar surface is also modified, and it would appear from its form that the patella itself must have rested fairly constantly against its lower part, thus hollowing it out and producing a definite ridge between this surface of the articulation and the inner condylar articular surface. In other words, it seems fairly certain that the position of the knee was one of almost continuous flexion.

The following table gives the measurements made upon the two bones:—

	Right femur.	Left femur.	
	mm.	mm.	
Maximum length	383	380	
Oblique length	378	379	
Diameter of head, vertical	43	43	
Diameter of head, transverse	42	43	
Size of head along curve, vertical	65	66	approximate owing to distortion.
Size of head along curve, transverse	75	74	
Maximum antero-posterior diameter of shaft	27·5	27	
Minimum transverse diameter of shaft	22	15·5	
Maximum width of internal condyle	28·5	23	
Maximum width of external condyle	26	24	

There are several points of interest exhibited by the above figures. Both femora are unusually short, and in the oblique direction are nearly the same length. But while in the right bone there is a difference of 5 mm. between maximum and oblique lengths, in the paralysed limb the difference only amounts to 1 mm. The difference in the right limb may perhaps be correlated with the constant adduction described above.

In spite of the distortion of the head of the left femur, its diameters are practically unchanged as compared with the right bone. This is of interest in view of the differences in the two humeri which were discussed above, and strengthens the view advanced, which attributes increase in size to greater muscularity. For in the lower limbs, as both do an equal amount of work under normal circumstances, they may be supposed to be of equal muscularity, and, as a matter of fact, there is, as a rule, very little to choose between the size of the head on the two sides, and whatever difference exists appears to be fairly evenly distributed between right and left sides in normal bones. In the present instance, with one limb paralysed, a definite difference in the size of the two femoral heads might have been expected; but the fact that, although the right limb was normal, it was unable to make much use of its muscles owing to the weakness of the left, probably explains the absence of difference in this case.

TIBIÆ (fig. 10).

These bones, like the ulnæ, exhibit less difference between themselves than do the other bones of the skeleton which have been considered. Nevertheless, even here the want of development on the left side is still apparent, and has resulted in a reduction in the antero-posterior diameter of the left bone, such that at the level of the nutrient foramen it is 5·5 mm. smaller than the right bone at the same level. The transverse diameter is not affected, the left bone being actually 1 mm. wider than the right. The articular surfaces are reduced in extent on the left side as described for the femora, both extremities exhibiting this change. The outer part of the inferior articular surface is rough and irregular, and it would appear that articulation with the astragalus must have been incomplete. Unfortunately, the latter bone was not secured. Both tibiæ are markedly twisted, and both exhibit retroversion of the head, a character commonly found in Egyptian bones, and especially well seen in those of predynastic times. Muscular markings are less pronounced on the left bone, and the groove for the tendon of the tibialis posticus is shallow and indistinct.

The measurements of the tibiæ are tabulated below for comparison:—

	Right tibia.	Left tibia.
	mm.	mm.
Length between articular surfaces	301	299
Length from superior articular surface to interior malleolus . .	312	309
Maximum antero-posterior diameter	29	23·5
Maximum transverse diameter .	21	22
Maximum width of tuberosities .	68·5	65·5

GENERAL CONCLUSIONS.

The anatomical characters having been described in detail, we may now attempt to reconstruct the picture which these facts make possible.

The pathological condition from which this ancient Egyptian suffered has been unanimously diagnosed as hydrocephalus by the authorities to whom the skull has been shown. It is abundantly evident that there must have been an excessive growth or distension of the cerebral hemispheres, commencing probably at a comparatively early period, but not early enough to interfere with the normal growth of the bones before they had assumed their distinctive and characteristic form. As, however, this pathological condition increased, it gradually brought about a partial left hemiplegia, owing no doubt to excessive pressure upon the motor centres of the right half of the cerebrum. In this connexion the very definite asymmetry of the skull, especially when looked at from below, must not be forgotten. It is plain from this that the pressure, whatever its nature may have been, was greater on the right side of the brain, and as a result we get the under-development of the left side of the body which is such a marked feature of the skeleton.

In regard to the upper limbs, it is quite clear that the right was employed more freely and frequently than the left. This is shown by two facts: (*a*) the enormous development of the muscular ridges for the pectoralis major and deltoid muscles; and (*b*) the much larger size of the articular areas, pointing to constant and vigorous movements at the joints. From the general appearance of the left arm, one is inclined to believe that it was not absolutely paralysed, and this is supported by the suggestion, for which the writer is indebted to Dr F. E. Batten, that the hemiplegia was spastic.

From the excessive size of the bony ridges for the attachment of the two muscles named above, the deltoid lifting the arm at the shoulder and the pectoral muscle either drawing it across the chest or acting from the humerus as a fixed point, lifting the chest up towards the arm, it would appear that some action in which these two muscles were constantly in request must have been habitually repeated. From this it is suggested that this man supported himself by the use of a long staff placed across the body so as to reach the ground on the left side, and grasped high up by the right hand, the left perhaps giving slight assistance. In this manner he could support his body momentarily while bringing the right foot forward, it being supposed that he got little or no support from the left lower limb. It may be mentioned that, when the writer advanced this idea at the meeting of the British Association in Dundee in September 1912, where this skull was exhibited, one of the audience stated that he had seen in Teneriffe a case of hemiplegia in which this mode of progression, with a long staff, was practised.

The results of such a hemiplegia are naturally far more evident in the lower limb, and such was seen to be the case in the examination of the bones. The absence of support on the left side for the trunk, with its enormous head, resulted in a tilting of the pelvis downwards and to the left, with the formation of a spinal curvature convex to the left in the lumbar region, but in all probability with a compensatory curve to the right in the thoracic portion of the vertebral column. This tilting of the pelvis produced the same effect on the right side as an excessive adduction of the right lower limb, and in consequence we find that the ligamentum teres, which is at its tightest in this position, has scooped out a notch for itself in the lower border of the articular surface of the right acetabulum. At the same time all the right adductor muscles were rendered useless by this very tilting of the pelvis, which constantly approximated their origins and insertions, and as a result the right side of the pubic arch failed to develop, not in this instance from paralysis of the muscles, but from simple inability on their part to do useful work.

Turning again to the left side, we find that the absence of the normal pressure upon the acetabulum from the head of the femur has resulted in a failure of that cavity to develop; it remains therefore shallow, while the irregular and irresponsible movements of the head of the femur in the socket have produced a corresponding irregularity, both of the femoral head and of the acetabulum itself. The limb not under muscular control, but still more or less fixed above, as regards position, by the ligaments of the hip joint, is lower down at liberty to go where it will. As is usual in spastic hemiplegia, it turns inwards at the knee, the leg and foot following; and this constant inward rotation of the lower end of the femur, acting on the fixed upper end, produces the remarkable torsion which we have seen exhibited by the left thigh bone. The limb is therefore dragged along, and the absence of normal muscular action reveals itself in the under-development of the bone and in the smallness of the condylar articular surface. The dropping of the left side of the pelvis almost certainly necessitated a flexion of the right knee, which was probably nearly constant, as evidenced by the extraordinary size of the area of attachment of the posterior crucial ligament, and the flattening of the posterior surfaces of the condylar articular areas.

The writer is indebted to Dr F. E. Batten, Sir Victor Horsley, and Mr T. W. P. Lawrence, to all of whom he showed the skull, for their opinions on the pathological condition which he has made use of in the course of the paper; and to Professor Thane for his suggestions and kind advice, which have always been of the greatest value.

The drawings were all made with the help of Martin's projection apparatus, and with the skull in the Frankfort plane

MEASUREMENTS OF EGYPTIAN HYDROCEPHALIC SKULL.

	Egyptian.	Modern English for comparison.
	mm.	mm.
Maximum length, from most projecting part of forehead to occiput	235·5	...
Glabello-occipital length	229·5	197
Ophryo-occipital length	230	195
Minimum frontal breadth	108·5	109
Maximum breadth	184	144·5
Bizygomatic breadth	143	141
Bimalar breadth	97·5	101
Basi-bregmatic height	158	146
Auricular height	146	127·5
Basi-nasal length	111	102
Basi-alveolar length	106	98
Upper facial height	71	78·5
Total facial height	121	127·5
Nasal height	53	57
Nasal breadth	26·5	25·5
Orbital breadth { right	44	43
Orbital breadth { left	44	44
Orbital height { right	32	36
Orbital height { left	32	36
Palate length	51	53
Palate breadth (estimated)	42	42
Interorbital breadth	28	22
Bigonial breadth	107·5	112·5
Height of symphysis	33	32
Height of sigmoid notch { right	53	63
Height of sigmoid notch { left	50	63
Breadth of ramus { right	40·5	33
Breadth of ramus { left	41·5	34·5
Circumference over greatest projection of forehead	660	550
Frontal longitudinal arc	180	150
Parietal longitudinal arc	178	140
Occipital longitudinal arc	152	125
Transverse arc { right	212	170
Transverse arc { left	205	167
Capacity	2901·4 c.c.	1767·5 c.c.
Cephalic index	80·1	73·3
Nasal index	50	44·7
Facial angle	0°	...

COMPARATIVE MEASUREMENTS OF EGYPTIAN HYDROCEPHALIC SKULL WITH CAMPBELL'S CASE OF HYDROCEPHALUS AND HIS CASE OF CEREBRAL HYPERTROPHY.

	Egyptian. Hydrocephaly.	Campbell's case. Hydrocephaly.	Campbell's case. Cerebral hypertrophy.
	mm.	mm.	mm.
Circumference	660	643	595
Glabello-occipital length . .	229·5	208	196
Basi-bregmatic height . .	158	155	141
Vertical index	69	74·5	71·9
Cephalic index	80·1	82·6	77·1
Minimum frontal diameter .	108·5	116	112
Maximum transverse diameter .	184	172	152
Frontal longitudinal arc . .	180	190	146
Parietal longitudinal arc . .	178	205	164
Occipital longitudinal arc . .	152	67	124
Total longitudinal arc . .	510	462	434
Basi-nasal length . . .	111	100	101
Basi-alveolar length . . .	106	94	94
Thickness of skull, frontal . .	R. 8, L. 8·5	3	10
Thickness of skull, occipital .	R. 8·5, L 9	5	12
Transverse arc, right . . .	212	200	194
Transverse arc, left . . .	205	210	187

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